AP® BIOLOGY
2010 SCORING GUIDELINES

Question 1

Homeostatic maintenance of optimal blood glucose levels has been intensively studied in vertebrate organisms. ***NOTE: Points for parts (a), (b) or (c) may be found in any part of the response.**

(a) Pancreatic hormones regulate blood glucose levels. **Identify** TWO pancreatic hormones and **describe** the effect of each hormone on blood glucose levels. **(4 points maximum)**

Identification of hormone 1 point each (2 points maximum)	**Effect of hormone on blood glucose levels 1 point each (1 point maximum per hormone)**
Insulin (humulin)	• Decreases/lowers blood glucose level.
Glucagon NOTE: A hormone name beginning with "gly-" is not acceptable.	• Increases/raises blood glucose level.
Somatostatin	• Increases/raises blood glucose level.

(b) For ONE of the hormones you identified in (a), **identify** ONE target cell and **discuss** the mechanism by which the hormone can alter activity in that target cell. **Include** in your discussion a description of reception, cellular transduction, and response. **(4 points maximum)**

• **1 point**: target cell • **1 point**: description of reception	• **1 point**: discussion of transduction • **1 point**: discussion of response of target cell

Insulin

- **Target cells**: Any cell except red blood cells, or brain cells unless specified as neuroglial cells.
- **Reception**: Insulin binds to a specific receptor (tyrosine kinase) on the cell surface.
  - Ligand binding to two adjacent monomers forms an active dimer (tyrosine kinase).
  - Dimer and other proteins become phosphorylated.
- **Transduction**: Binding of signaling molecule alters the receptor protein in some way.
  - Stimulates a cascade pathway/mediated by a second messenger/amplifies signal.
- **Response**: Transduced signal triggers a specific action by the target cell. Specify one of the following:
  - Increases/raises cellular uptake of glucose.
  - Increases formation of glycogen from glucose in liver/(skeletal) muscle cells as intracellular glucose is incorporated into glycogen (glycogenesis).
  - Increases rate of intracellular catabolism of glucose.
  - Increases fat synthesis from glucose in liver cells and adipose tissue.
  - Decreases gluconeogenesis, the conversion of amino acids and glycerol from fats to new molecules of glucose.
  - Phosphorylated transcription factors can alter gene expression.
  - Facilitated diffusion of glucose. (Glucose is phosphorylated into glucose-6-phosphate to preserve the concentration gradient so glucose will continue to enter the cell.)
  - Cells with more glucose transporters increase departure of glucose from blood.

Question 1 (continued)

Glucagon

- **Target cells**: Liver cells, (skeletal) muscle cells.
- **Reception**: Binds to a specific receptor on the cell surface (G-protein-coupled receptors on liver cells).
    - G protein-GTP activates adenylyl or guanalyl cyclase.
- **Transduction**: Binding of signaling molecule alters the receptor protein in some way. (G-protein binds to GTP and this activates other signal molecules such as adenylyl cyclase/amplifies signal.)
    - cAMP or cGMP active as second messenger/phospholipase C activation releases IP3 and DAG.
    - Kinase activation by cAMP or cGMP/phosphorylated effector proteins.
- **Response**: Transduced signal triggers the specific action by the target cell. Specify one of the following:
    - Releases glucose into the bloodstream from liver.
    - Increases breakdown (hydrolysis) of glycogen (glycogenolysis) to glucose in liver/(skeletal) muscles.
    - Increases gluconeogenesis, the conversion of amino acids and glycerol to glucose in the liver; new glucose enters the blood.
    - Decreases glucose breakdown/oxidation.
    - Increases glucose formation (gluconeogenesis).
    - Ca^{2+} release.

Somatostatin

- **Target cells**: Pancreatic cells (alpha and beta cells).
- **Reception**: Binds to a specific receptor on the cell surface (G-protein-coupled receptor).
    - G protein-GTP activates adenylyl or guanalyl cyclase.
- **Transduction**: Binding of signaling molecule alters the receptor protein in some way.
    - cAMP or cGMP active as second messenger/Phospholipase C activation releases IP_3 and DAG.
    - Kinase activation by cAMP or cGMP/phosphorylated effector proteins.
- **Response**: Transduced signal triggers the specific action by the target cell. Specify one of the following:
    - Decreases insulin secretion (from beta cells).
    - Decreases glucagon secretion (from alpha cells).
    - Ca^{2+} release.
    - Guanine nucleotide binding protein (GNAI 1) inhibits insulin.

(c) Compare the cell-signaling mechanisms of steroid hormones and protein hormones. **(4 points maximum)**

Steroid hormone (2 points maximum)

- Mechanism of action — to alter gene expression in the target cell.
- Hydrophobic/lipophilic/nonpolar/fat-soluble molecules readily cross cell or nuclear membrane.
- Acts as ligand that binds to cytosol receptors.
- Binding changes the conformation/shape of the cytosol receptor; hormone-receptor complex then enters the nucleus as the activated transcription factor.

Question 1 (continued)

- Transcription from the genes is affected:
  - Releases HDACs and recruits HATs — histone acetylases — to end chromosome repression.
  - Complex acts as a transcription factor that binds to a promoter (including HRE, hormone response element).
- Actions are slow but sustained.

Protein hormone (2 points maximum)

- Mechanism of action — to activate biochemical pathways/enzyme systems OR alter gene expression in a target cell.
- Hydrophilic/lipophobic/polar/water-soluble molecules do not readily cross cell membrane.
- Acts as ligand for membrane-bound receptors. Binds to receptor transmembrane proteins (either tyrosine kinase or G-protein receptors).
- Hormone is the ligand and the first messenger.
- Actions are brief but dramatic.